CEPHALOCHORDA.

I. SYSTEMATIC AND ANATOMICAL ACCOUNT.

By C. Forster Cooper, B.A., *Trinity College, Cambridge.*

(With Plate XVIII. and Text-figures 76—89.)

II. NOTE ON MERISTIC VARIATION IN THE GROUP.

By R. C. Punnett, M.A., *Fellow of Gonville and Caius College, and Demonstrator of Comparative Anatomy in the University of Cambridge.*

I. SYSTEMATIC AND ANATOMICAL ACCOUNT (By C. Forster Cooper).

CONTENTS.

The following is an account of two species of *Amphioxus* from the Maldive region, one of which, viz. *Heteropleuron maldivense*, is new and related to *H. bassanum*. An account is also given of some larvae, the adults of which are uncertain.

I take this opportunity of thanking Mr Adam Sedgwick for permission to work in his laboratory, and for the great interest he has taken in the work. I am also indebted to Mr J. J. Lister, Major Alcock, Mr R. C. Punnett and Mr Crossland for specimens from other localities in the Indian Ocean. I would also thank Mr A. E. Shipley for the encouragement he has at all times shewn me.

1. ASYMMETRON LUCAYANUM (Andrews). Pl. XVIII. fig. 1.

This species of Cephalochorda is by far the most abundant in the Maldives, occurring roughly in the proportion of 100 to 1 of the only other form found (*Heteropleuron maldivense*). It seems to be identical in almost every particular with the form described by Andrews from the Bahamas[1].

The only point in which the Maldivan and W. Indian forms consistently differ from one another is in their size. The average length of the Maldivan specimens is 23 mm., the extremes being 18 and 30 mm., thus being nearly double the length of the Bahama specimens which Andrews found to average 13 mm. In spite of this difference the average myotome formula for the two forms remains practically the same, the mode in each case being 66 myotomes, *i.e.* 44 from the head to the atriopore, 9 from the atriopore to the anus, and 13 from the anus to the tail.

The most prominent external feature of the species is the long caudal extremity which at once differentiates it from all other known forms of Cephalochorda. There is a narrow rostral fin round the anterior end of the notochord, which projects some 2 mm. beyond the end of the first myotome. This is continued dorsally as a low fin running the whole length of the body to the tip of the caudal extremity. Owing to the taper of the body the fin is rather deeper for the last fifteen myotomes (*i.e.* from about the level of the anus to the caudal extremity). From the last myotome to the tip of the tail it narrows down to a point.

The ventral fin is a continuation of the right metapleural fold, and like the dorsal fin it also broadens out for the last fifteen myotomes, though somewhat deeper than the last named. It bends up suddenly at the last myotome, and becomes the ventral part of the narrow tapering caudal fin. The depth of the dorsal and ventral halves of the latter fin is the same.

In the dorsal fin from about the 17th to the 32nd myotome there are fin-ray spaces containing small blocks of cartilage, the fin rays. These begin anteriorly as small irregular blocks, which gradually increase in size and become more regular, averaging two to a myotome; towards the tail they again decrease in size. There is, however, much variation in different specimens both in the number and size of the fin rays. The ventral fin possesses neither fin rays nor fin-ray spaces.

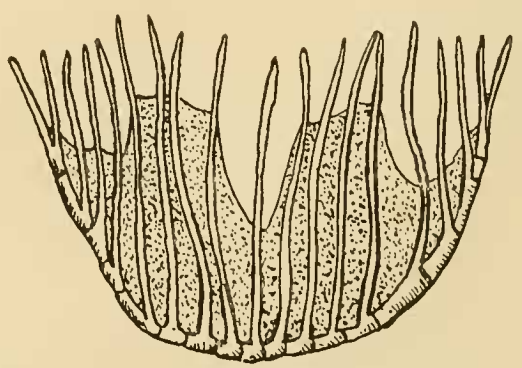


Fig. 76. Buccal cirri of *Asymmetron lucayanum*.

In comparison with *Amphioxus lanceolatus* the general shape of the species is long, thin, and somewhat narrow from side to side. The metapleural folds end short of the buccal hood, and do not in any way connect up with it. The buccal hood is long and shovel-shaped, but not very deep. The buccal cirri number 19, and are divided into two groups on each side of a median unpaired tentacle. The outer group on either side consists of five tentacles joined together by a low membrane, whilst each inner group possesses four tentacles connected by a high membrane which reaches fully three-quarters of the way up the cirri (Fig. 76).

[1] *Stud. Johns Hopkins Biol. Lab.* vol. v.

The tentacles are smooth and without any sensory patches.

The preoral pit is large, and in structure is similar to that of *A. lanceolatus*. The blood vessel running with it breaks up into a glomerulus, in which the vessels are less in number but of a larger sectional area than usually obtains in the European species. In this point there is some variation, certain of the specimens approaching more nearly to the former type, others more to the type as described by Andrews.

The "Räderorgan" is large and well formed. It consists of a large dorsi-lateral arm on each side of the buccal hood, and thin secondary arms with smaller loops in between. The dorsal arm of the left side is longer than that of the right, and connects up with the preoral pit. The whole organ forms a ring of tissue round the base of the buccal hood, the arms being pulled out along its sides.

The mouth and velum underlie the apex of the eleventh myotome. There are eight velar tentacles. The pharynx stretches between the level of the apices of the 10th to the 45th myotome, thus occupying a space a little over half the total length of the body. Both mouth and pharynx as well as the alimentary canal are similar in structure to the corresponding organs in *A. lanceolatus*. The skeletal bars of the gills are normal in general plan, but the synapticulae joining the bars together are only three in number and very slender.

The nervous system presents no great peculiarities, the most noticeable feature being the absence of the olfactory pit, no traces of which could be found. The nerve cord stretches to the tip of the caudal extremity as a very fine thread. Special nerves are given off only in the region of the myotomes. Beyond this point, *i.e.* in the caudal extremity, no nerves arise from the nerve cord.

The excretory system consists solely of patches of epithelium on the floor of the atrial cavity. No trace of nephridia on the gills could be seen, nor could Lankester's brown funnels be traced. Andrews was similarly unable to find these in the Bahama form, so that their non-existence seems certain.

The circulatory system (of which only the main vessels were traced) is similar to that of *A. lanceolatus*.

The gonads are placed on the right epipleur, and are twenty-nine in number, lying from the 14th or 15th to the 43rd or 44th myotomes. The first few gonads are small. They present a gradual increase in size till the centre of the series is reached, after which they again begin to decrease, the last few gonads being of the same size as the first. The period of sexual maturity seems to bear no relation to the size of the animal. Very small specimens were found with well developed gonads (always 29 in number), while some of the largest obtained, measuring 30 mm., had them very little or not at all developed.

2. HETEROPLEURON MALDIVENSE. Pl. XVIII. fig. 2.

This species is by no means common in the Maldive Islands, only four specimens being obtained from Mahlosmadulu Atoll. None were found in the lagoon of the Island of Minikoi, and since Mr Gardiner searched this locality extremely carefully during the months of June, July, August and September without finding either adults or larvae, it may be concluded that it does not occur there.

Heteropleuron maldivense more closely resembles *H. bassanum* (Günther) from Bass' Straits, Australia, than any other species in the genus. It is somewhat similar to this species as figured by Kirkaldy[1] but differs in the shape of the fins, in being of much smaller size, and in some other small particulars.

As there is no account of the anatomy of *H. bassanum*, it is not possible to say whether that species shares the peculiarities of the form here described.

The largest specimen obtained measured 2 cm.[2] (*H. bassanum* averages 4·3 cm., Kirkaldy). The depth is rather large in proportion to the length (Plate XVIII. fig. 2). The dorsal fin is rather narrow posteriorly but becomes broader as it approaches the head, being at its greatest depth about one-sixth of the total depth of the body. It runs forward with only a very slight notch into the moderately-sized rostral fin. It is throughout its length provided with fin-ray spaces and long fin rays closely crowded together. These number between three and four to the myotome, the rays becoming shorter and slightly broader posteriorly.

The rostral fin runs forward for a short way and then bends round the snout, and continues ventrally for a short distance until it finally joins the buccal hood on the left side. The ventral fin has the same depth as the dorsal fin in the corresponding region; it is a continuation of the right metapleural fold, and has single fin-rays and fin-ray spaces, differing in this respect from *H. bassanum* where they are paired.

The caudal fin is lance-shaped and, in comparison with *Amphioxus lanceolatus*, rather narrow. The ventral half is a little deeper than the dorsal. Both the superior and inferior angles are very slight.

The myotome formulae of the four specimens were

	Number of myotomes from		
Total No. of myotomes	Head to atriopore	Atriopore to anus	Anus to tip of tail
73	45	16	12
74	45	16	13
72	46	16	12
75	46	16	13

The average given by Kirkaldy for *H. bassanum* is

75	45	16	14

Anatomy. This species on the whole is similar to *Amphioxus lanceolatus* in its larger features, but presents some minor differences. The preoral pit is rather small compared with that of *A. lanceolatus*, running halfway up the side of the notochord (Fig. 77). Further back it comes to lie high up on the left wall of the buccal hood (Fig. 78). Except at the point where it runs up at the side of the notochord it is very shallow. The blood vessel, which runs above it, is divided at most into two or three vessels, instead of breaking up into a glomerulus as in *A. lanceolatus*.

The "Räderorgan" consists of one median dorsal loop, in the left side of which is placed the preoral pit. Each wing of this loop runs back towards the velum, and then forward again to form the four or more secondary loops on the sides of the buccal hood. The two epithelial tracts join on the base of the velum and complete the ring.

[1] *Q. J. M. S.* vol. xxxvii. (1895).

[2] Table II. in Mr Punnett's account of the Meristic Variation.

The buccal hood is chiefly noticeable for the great extent and thickness of its gelatinous walls, a feature also of the whole front part of the animal.

A section just behind the region, where the rostral fin runs into the apex of the buccal hood, shews the great general development of the gelatinous tissue, when compared with the area occupied by the muscles, &c. (Fig. 79). It will be noticed that in the section figured, the tips of the buccal cirri have been cut through at this level.

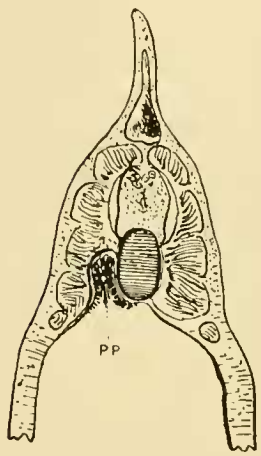


Fig. 77.

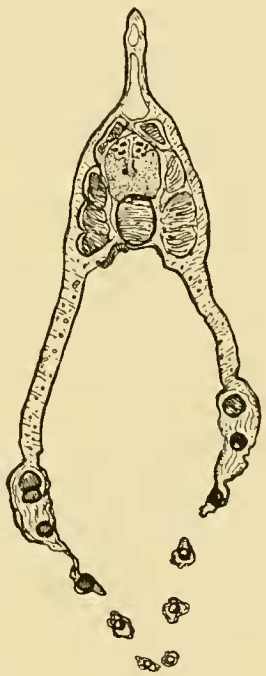


Fig. 78.

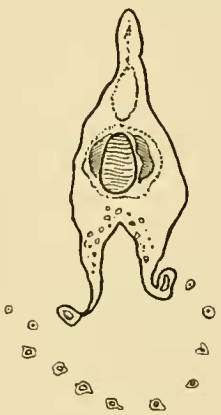


Fig. 79.

Fig. 77. *Heteropleuron maldivense.* Section through the middle of the preoral pit (*P.P.*).

Fig. 78. *Heteropleuron maldivense.* Section through the end of the preoral pit, showing the great development of the hood.

Fig. 79. *Heteropleuron maldivense.* Section through the anterior end of the head immediately behind the rostral fin. The buccal cirri are cut through near their free ends.

The side walls of the hood as they proceed backwards gradually become deeper, and at their lower edges appears the ring of cartilage from which the buccal cirri spring. The hood is of a broad shovel-shape, and the buccal ring thus has a V-shape with a pointed apex and rounded sides. The cirri are 23 in number and are webbed half-way up their extent except the last four on each side, which are small and free. Sections at different levels in front of the velum shew the development of the hood (Figs. 78—80). In the front part of the hood are a number of lymph spaces which traverse the gelatinous substance, and frequently anastomose with one another.

The gill slits in general structure are precisely similar to those of *A. lanceolatus* as are also the branchial skeleton and endostyle. In one specimen a primary bar was found, possessing two skeletal rods (Fig. 81), joined together at their base. They almost directly separated and

ran up side by side, and there was only one division of the coelom as figured. According to Benham this is a fairly common variation in *Amphioxus lanceolatus*[1].

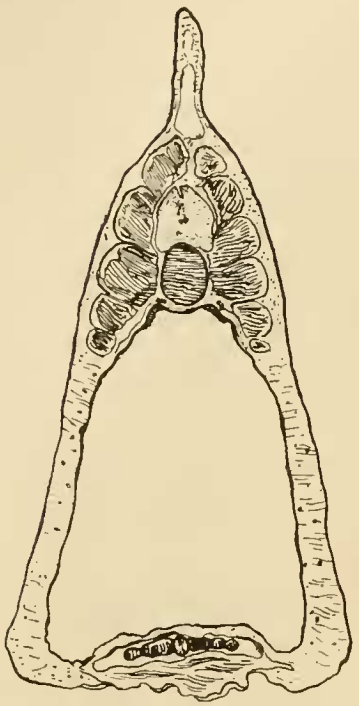


Fig. 80. *Heteropleuron maldivense*. Section just in front of the velum. The origin of the buccal cirri is seen at the bottom.

The alimentary canal from the region of the atriopore stretches through 21 myotomes to the anus. The liver caecum is comparatively short, running through only nine myotomes.

The excretory organs are of the usual type. The epithelial patches on the floor of the atrium are numerous and well-marked. Nephridia on the gills could also as a rule be seen. They have the usual structure as described by Goodrich[2], and their atrial openings were distinctly observed. Lankester's brown funnels do not occur.

The circulatory and nervous systems both conform to the usual type, but in the latter no olfactory pit was found. Only the gross anatomy of these organs could be made out, but as far as the histology was observed, there is no difference between them and the same organs described for *A. lanceolatus*.

Since working out this form I have received a large number of specimens of *H. maldivense* from Mr Crossland, who obtained them at Zanzibar. I have been thus enabled to make a fuller list of measurements, which shew that the size of the animal may be larger than the Maldivan specimens led me to expect, although the average remains about the same. These measurements will be found in Table II. p. 363 of Mr Punnett's "Note on Meristic Variation in the Group." Unfortunately the specimens were not very well preserved. The gonads had in some cases broken away, and in others, marked with a note of interrogation (?), their position was a little doubtful.

To sum up the specific differences between this form and *H. bassanum*. The myotome formula is on average 73 in all, 45 from the head to the atriopore, 16 from the atriopore to the anus, and 12 from the anus to the tail; while the total number in *H. bassanum* is nearly the same, *i.e.* 75, there is a constant difference of two myotomes in the caudal region, *H. bassanum* having 14. The dorsal fin is much deeper than in *bassanum*, the rostral fin is a little smaller and the notch is very much less marked. The preoral cirri number 23 as against 33, and the ventral fin is without the paired fin rays and spaces[3].

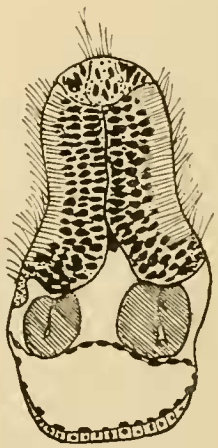


Fig. 81. *Heteropleuron maldivense*. Abnormal double gill bar.

3. BRANCHIOSTOMUM PELAGICUM.

Through the kindness of Mr J. J. Lister I have been enabled to examine a specimen of an *Amphioxus*, which was obtained by him in the year 1888 in latitude 21° 16′ S. and longitude 80° 50′ E. *i.e.* in the

[1] *Quart. Journ. Mic. Sci.* 1893, vol. xxxv. Part 1.

[2] *Quart. Journ. Mic. Sci.* 1900, vol. xviii. Part 4.

[3] Dr Benham (*Q. J. M. S.* vol. xliv. p. 276) states that double fin rays do not occur in the ventral fin of *H. bassanum*. Kirkaldy (*loc. cit.*), however, avows that her specimens were in good condition, so that a mistake could hardly have been made. Variation in this respect may occur.

centre of the Indian Ocean about half-way between Madagascar and Australia. The depth at which it was taken cannot be stated with any certainty, as it came up in a dredge which had been working in 800 fathoms. It may thus have been taken on the bottom or enclosed in the net as it was hauled up.

The form on examination proves to be a specimen of *B. pelagicum*, the only other known example of which was taken by the Challenger in 1875 in the open Pacific, and which was described by Günther in the Challenger Report on the pelagic fishes. The specimen considered here was unfortunately in so bad a condition, both externally and internally, that it was impossible to work out its internal anatomy, either by sections or by mounting whole. The Challenger specimen was almost equally bad, so that until fresh and better preserved specimens are obtained, we must remain ignorant of its organisation, which should prove interesting.

Fig. 82. *Branchiostomum pelagicum.* View of the preserved specimen. The branchial region is seen on the under side to the left.

In length the specimen is 21 mm. and it possesses 60 myotomes (the exact number is uncertain owing to decay), while the Challenger specimen had 67 myotomes. The tail fin is broad and lance-shaped, the dorsal and ventral halves being equal (Fig. 82). For the size of the animal it is extraordinarily well-developed, a condition which lends colour to the view that it is a true pelagic organism. A very narrow dorsal fin runs forward from the tail to the head, and an equally narrow ventral fin is present, the precise length of which could not be made out.

The shape of the head is peculiar, being tapered and ending in a pronounced snout. No trace of buccal cirri could be seen either when viewed sideways or when cut into sections. It would indeed seem that the absence of buccal skeleton is a real character, and not due to maceration or loss, none being found in the Challenger specimen. The structure of the branchial region could not be well seen, owing to the bad preservation of the inner parts of my specimen. It appeared however to be peculiarly small in extent, and quite similar to Günther's figure of the Challenger specimen.

4. PELAGIC LARVAE. Pl. XVIII. figs. 3—6.

Although larvae of *Amphioxus* were throughout found to be far from common, about a dozen were taken in the south of Miladumadulu Atoll and in Fadifolu Atoll, during rough and stormy weather in the last fortnight of December, 1899. They were caught at sundry depths from 8 to 20 fathoms. All were secured during the night in the channels leading from the open sea to the atoll lagoons by hanging tow-nets at different depths over the stern of our schooner, in such a manner as to keep them well swung out by the currents, which drive the various forms of the plankton into them.

It cannot be ascertained with any certainty whether the larvae are those of *Asymmetron*, *Heteropleuron* or of some other form the adult of which we did not obtain. There are many reasons, derived from the anatomy of these larvae, why they should not belong to *Asymmetron*, in spite of the fact that this form is present in our collections in the proportion of one hundred or more to one of *H. maldivense* (the only other form found).

The larvae evidently all belong to one and the same species, and, although they do not form a series extending over any considerable period of development, seem to possess some features worth describing. They are all in nearly the same stage, but owing to the unusual nature of their gill clefts, cannot be compared at all closely in point of age with the well-defined stages in the larval history of *Amphioxus lanceolatus* as described by Willey[1].

In shape and external appearance the larvae are not unlike those of *A. lanceolatus* when both are viewed from the side (Pl. XVIII. figs. 3 and 4). There is a moderate-sized dorsal fin extending from the tail to about the level of the end of the pharynx, in front narrowing down to half its previous width, and continuing forward with the same breadth to the front end of the body. The tail fin is lance-shaped, the dorsal and ventral halves being of precisely the same depth. The ventral fin is a continuation of the tail fin, and is similar to, but slightly deeper than, the corresponding part of the dorsal fin. It extends rather further forward than the broad part of the latter, and passes to the right side of the anus.

The youngest larva in the collection measures 5·75 mm. in length and 1·5 mm. in depth (Pl. XVIII. fig. 3), and possesses 60 myotomes. Its external form is as described above, and it has 14 gill slits on the ventral side open to the exterior throughout. A stout notochord of typical structure runs throughout the body from the tip of the snout to the extreme end of the tail.

The central nervous system commences in the second myotome, and extends to the extreme end of the tail, the last part being very slender. The eye spot (Fig. 83) consists of a round mass of black pigment situated on the upper wall of the brain cavity at a little distance from its front end. It is of comparatively large size, and projects into the lumen of the cavity in such a manner as to almost fill it. The eye thus differs a little in position and shape from that found in *A. lanceolatus*, where it is a conical cap of pigment placed on the front end of the brain. The anterior dorsal nerve is very conspicuous, and the spinal nerves are given off in the usual manner. The olfactory pit is placed almost immediately behind the eye spot. Except in being of a rather smaller size it in no way differs from that of *A. lanceolatus*. The presence of this structure proves that these larvae cannot be considered to be the larvae of the Maldive *Asymmetron*, in which it does not occur.

[1] Willey, *Amphioxus and the Ancestry of the Vertebrates.*

The preoral pit is at this stage large and well-formed. At its extreme anterior end it originates as a small knob of tissue projecting into the head cavity (Fig. 84 *PP.*). In this an invagination commences, which rapidly increases in size as it proceeds backwards. On the dorsal side of the pit appears the preoral sense organ (Fig. 85 *P.S.O.*), a ciliated gutter which after proceeding backwards for a short way ends blindly in front of a forward prolongation of the pharyngeal region, the lumen of which opens directly behind the groove (Fig. 86). As shewn in the figure there are two of these blind caeca running up from the pharyngeal region, one dorsal and one ventral to the preoral pit; their walls at the ends are glandular.

The club-shaped gland begins a little in front of the larval mouth opening. It is similar in shape to that described for *A. lanceolatus*, and has the opening in the dorsal arm—by which its cavity is put in connection with that of the pharynx—well-marked. No opening, however, could be found in the lower arm connecting it with the exterior as described by Willey[1]. In this early stage the endostyle is not very far advanced. It shows only as a patch of modified epithelium lying immediately in front of the club-shaped gland.

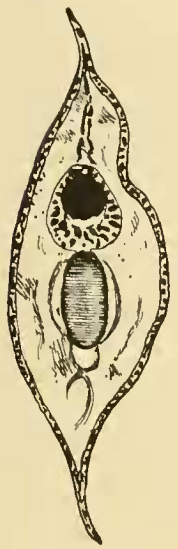


Fig. 83.

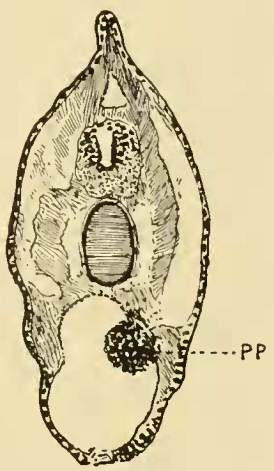


Fig. 84.

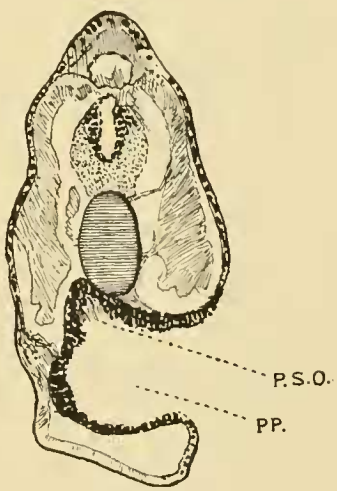


Fig. 85.

Fig. 83. Larva. Transverse section passing through the eye.

Fig. 84. Larva. Section through the anterior part of the preoral pit (*PP*).

Fig. 85. Larva. Section through the middle and largest part of the preoral pit (*PP*). The preoral sense organ (*P.S.O.*) lies dorsally and to the left of the notochord.

The mouth is a small elongated slit lying on the left side about one-third of the way up from the ventral side. The obscure organ termed Hatschek's nephridium lies on the left side just under the notochord and runs into the pharynx.

The first gill slit opens under the mouth and a little to the left of the mid-ventral line (Fig. 87 *G.S.I.*). The next two slits also lie somewhat to the same side gradually approaching the mid-ventral line, in which the rest are placed. The right metapleural fold arises at a more forward level than the left, which starts from the hind corner of the mouth between the second and third gill slits. It rapidly increases in size until it equals its fellow of the right side. Between these folds the gill slits occupy a mid-ventral position.

[1] Willey, *loc. cit.*

On each bridge of tissue between the gill slits the branchial epithelium projects as a mass of large columnar cells with darkly staining nuclei (Fig. 88). Many sections, but by no means all, give an appearance of having the branchial epithelium split into two (Fig. 89)[1]. The latter extends alternately down each side of a slit, so that every slit has the branchial epithelium

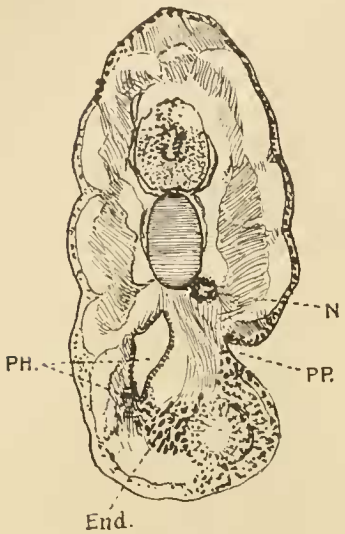


Fig. 86.

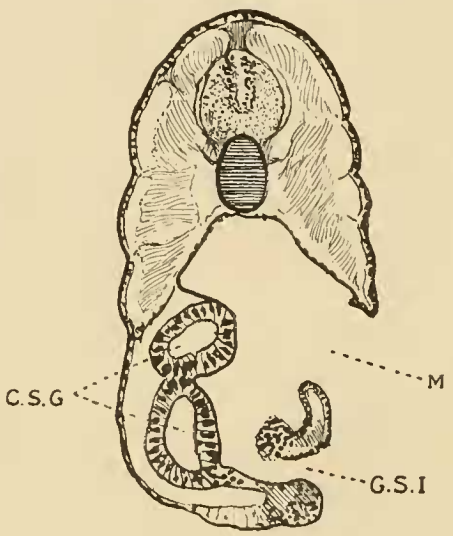


Fig. 87.

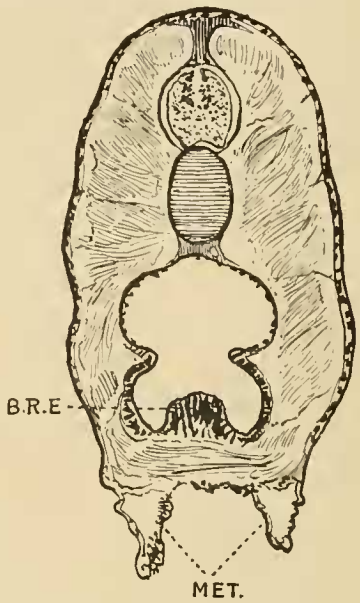


Fig. 88.

Fig. 86. Larva. Section through the extreme posterior end of the preoral pit (*PP.*), showing Hatschek's nephridium (*N*), the commencing formation of the endostyle (*End.*) and the two prolongations of the pharynx (*PH.*).

Fig. 87. Larva. Transverse section passing through the mouth (*M*) and first gill slit (*G.S.I.*). The two arms of the club-shaped gland (*C.S.G.*) are also shown.

Fig. 88. Larva. Section through a part between two gill slits showing the metapleural folds (*MET.*) and the branchial epithelium (*B.R.E.*).

on the opposite side to the one preceding and following it. The meaning of this is not clear, and can only be solved satisfactorily by the examination of later stages.

Springing from the middle of the pharynx are the true hyper-pharyngeal bands. The left-hand band arises immediately behind the mouth, that on the right hand commencing directly behind the club-shaped gland. They both extend through the whole length of the pharynx, and die out at the beginning of the intestine. The latter itself is normal. The glandular patch in the rectum in all these larvae is very noticeable.

Fig. 89. Larva. Section to the right through a gill slit and to the left intermediate to two slits. The left section shows the appearance of splitting found occasionally in the branchial epithelium.

In a later stage (Pl. XVIII. figs. 4 and 5), also having 60 myotomes, various changes are found to have taken place. The endostyle has become fully formed, and has acquired all the essential histological features found in the adult. It still, however, lies in the larval

[1] I am unable to say whether this phenomenon has any real meaning, or is merely due to the combined effects of preservation and section cutting.

position, and has not yet taken up its permanent location on the ventral side of the pharynx, which shews that a certain amount of torsion still has to take place. It now extends over and beyond the club-shaped gland for some distance. The two arms of the latter organ have become histologically differentiated, the upper arm having a large lumen with tall glandular cells, the lower arm being drawn out into a tube with a small lumen and much smaller cells.

The preoral pit now leads right down to the front end of the larval mouth as a narrow gutter, open to the exterior throughout its whole length. The buccal hood has not yet begun to grow out.

In this larva the gill slits numbered 31. As in the younger form all the openings lie in a series one behind another in the mid-ventral line. Plate XVIII. fig. 5 shews the ventral view of this larva. The appearance of the slits in the mid-ventral line is curious, for the reason that the bridges between the openings are very long and narrow. Owing to this they have become much twisted, and their shape somewhat obscured. Their form can, nevertheless, be traced out, and it is seen that they have a somewhat rectangular shape. There is no sign of any crescent-shaped infolding to form a tongue bar. There is absolutely no trace of any secondary gill slits breaking through in the manner usually described—that is, on the right side and above the primary slits. Normally the secondary slits should shew, at their first origin, as six oval thickenings situated on a continuous ridge of tissue, in the right wall of the pharynx above the primary slits, and this should take place when the larva has fourteen primary slits fully formed. As has already been seen the first larva possessed the requisite number of primary slits without signs of the appearance of any secondary ones. Further, in the normal development, the formation of the secondary slits, after they have once started, is very quick, and the number of slits on each side becomes even. A certain number of primary slits close up and a stage with eight on each side is reached.

Indeed, the phenomena found in these larvae cannot be brought into any uniformity with the plan of *A. lanceolatus*. In none of the specimens obtained is there any sign of secondary gills, although possessing from 15 to 31 'primary' slits. It seems impossible that after such a late stage has been reached, the secondary slits should arise by perforation in the usual place, especially now that the metapleural folds have been well formed. What precisely does occur it is impossible to say owing to the lack of the later stages which only could throw light on the subject. For the same reason one cannot say whether any of the slits present close up as do some of the primary slits in the larva of *A. lanceolatus*.

Such evidence as there is, points to some different method of origin of the gills to that which is found in *A. lanceolatus*, the only species in which the full development has been thoroughly observed. There is no reason why all species should have precisely the same way of development, but unfortunately the facts here are hardly sufficient to warrant any deductions as to how the gills arise in the present peculiar form.

The fact that the larvae were taken right away from the grounds where the two Maldivan species of *Cephalochorda* were found, and also that they were taken in heavy weather close to the channels leading from the sea, makes it possible that they may be the larvae of some pelagic form, whose altered mode of life may account for the differences of larval growth mentioned above.

5. DISTRIBUTION AND HABITS OF THE MALDIVAN CEPHALOCHORDA.

1. *Asymmetron lucayanum.*

In the Atoll of Minikoi, which was very thoroughly searched by Mr Gardiner between the months of June and September, many specimens of this form were obtained. Their distribution in the atoll proved to be very local, and although many places at first sight seemed to be suitable they were restricted to practically one spot—viz. the Neru-Magu channel (*vide* Chart, Part I. page 28 of the present work), on the N.W. side of the atoll, which runs in across the sand-flat with a depth of about 2 fathoms. The sides of the channel were of sand and rather steep. The bottom was found to be of rock covered with a few inches of sand and studded with small growths of corals. It was in the shallow sand at the bottom of the channel that the specimens were found.

Very careful search in the sand at the S.W. part of Minikoi lagoon, which is covered by shallow water, revealed only one specimen, and none were found in any other part of the lagoon, except close to the channels from the sea. A few specimens were kept alive for several days in a basin covered with fine silk gauze and sunk in the lagoon. Their dislike to strong light, recorded by Andrews[1], was observed, and Mr Stanley Gardiner also informs me that they were never seen to lie on their sides on the surface of the sand as the European species commonly does.

The distribution in the Maldives is also local and peculiar, specimens often being found in small numbers at unexpected depths and places. A list of the localities and depths is here given.

(1) *Suvadiva Atoll.*

Two specimens were obtained from a hard bottom consisting of rough stony rubble with masses of weed and calcareous algae. 29—30 *f.* (*fathoms*).

(2) *Mahlosmadulu Atoll.*

A few specimens from coarse sand mixed with a little rubble, about 20 *f.*, near Turadu and Duravandu Islands: in the *velu* (lagoon) of the island of Berriamfuri several were secured off the sandy bottom, 3—4 *f.*

(3) *Fadifolu Atoll.*

Several were dredged from a bottom consisting of rough corals, weeds and sponges, in the channel to the north of Naifaro, 15 *f.*, and a few also from a hard bottom with weeds and a little sand, 23 *f.*, near the centre of the lagoon.

(4) *Miladumadulu Atoll.*

Two or three came from a large block of *Porites* which was dredged up, being found in sand which had collected in small quantities in the crevices of the coral, 20 *f.* Several were taken in the sand of the *velus* of the islands of Mafaro and Edufaro, 3 *f.* In Furnadu the shallow sand-flat (2—3 *feet*) between the islands of Furnadu and Farukolu, an area swept by strong tidal currents, yielded a number of specimens.

(5) *Male Atoll.*

In the island of Hulule, where a longer stay than usual was made, a large number of specimens were secured and their distribution was carefully studied. Five only were obtained

[1] *Loc. cit.*

in the *velu* which is a sandy area of considerable size and with an average depth of from 6 to 7 fathoms. Five specimens were also brought up from a depth of 25 fathoms off the west reef of the island, *i.e.* in the main lagoon of the atoll from a bottom of decaying rock and sand.

By far the largest number, however, came from a particular spot at the south end of the *velu*, just to the north of the north-west point of Hulule island. From this end of the island a sand spit runs out for a distance of some 70 yards, the greater part covered at low water. The sand at the end of this spit suddenly dips down into a channel which at low tide never had less than 4 feet of water in it. This channel was about 30 yards across its widest part and ran east and west at right angles to the length of the island. At the further end of the channel was another sand spit of about 50 yards breadth which gradually sank into the *velu*. A current at almost all states of the tide ran up or down the channel, often with considerable force, keeping the sand at the bottom and sides in a continual state of motion, and it was in this sand that *Asymmetron* was found to be most abundant. About two hundred were actually obtained, but any quantity could have been caught if desired. They were taken by wading out into the channel and dipping a sieve into the sand, a dozen or more being often caught in one lot.

It would thus appear that the chief and most favourable habitats are moderately shallow and sandy channels, as in this place, in Furnadu, and in the channel in Minikoi, the three places in which the greatest number were found. In all other places, where there was a greater depth and an absence of current and sand, only a few odd specimens were taken. There were several places visited in which the conditions seemed to be quite suitable for *Amphioxus* but in which no specimens were found. This was notably the case off Goidu in Goifurfehendu Atoll. The reason for this very local distribution is not easy to explain, but it was noticeable that wherever *Asymmetron* was abundant, other sand-living animals were absent or very scarce[1].

The distribution of this species from a larger point of view is interesting. Mr Crossland obtained a few in Zanzibar, but no other specimens are recorded from the Indian Ocean. The only other locality so far recorded is the Bahamas in the West Indies, where they were first obtained by Andrews.

2. *Heteropleuron maldivense.*

The number of specimens found in the Maldives is too small to admit of any deductions as to habitat. Three specimens were found in Mahlosmadulu in coarse sand at a depth of 20 fathoms, and one specimen in a channel into Fadifolu at a depth of 15 fathoms. Mr Crossland, who found a large number of this species in Zanzibar, informs me that they were taken on sandy bottoms at a depth of 7 to 8 fathoms.

The following *Cephalochorda* have now been recorded from the Indian Ocean:—

1. *Amphioxus belcheri* Gray. Madras, 6 fathoms, off "Seven Pagodas, Mahabili," dredged by Major Alcock; and Singapore, several larvae and a few adults. This species also occurs in Prince of Wales Island, Torres Straits and Borneo.

2. *Asymmetron lucayanum* Andrews. Maldive Islands, Minikoi and Zanzibar. The species is found also in the West Indies.

[1] In this connection it may be remarked that *Asymmetron* is a discriminate feeder. It lives on particles of vegetable matter, and does not swallow sand, as do many other sand-living organisms.

3. *Heteropleuron cinghalense* Kirkaldy. Coast of Ceylon.

4. *H. maldivense,* n. sp. Maldive Islands and Zanzibar.

5. *Dolichorhynchus indicus* Willey. "Black Pagoda," off the Orissa coast of India.

6. *Branchiostomum pelagicum* Günther. One specimen each from Indian and Pacific Oceans.

DESCRIPTION OF PLATE XVIII.

Fig. 1. *Asymmetron lucayanum.*

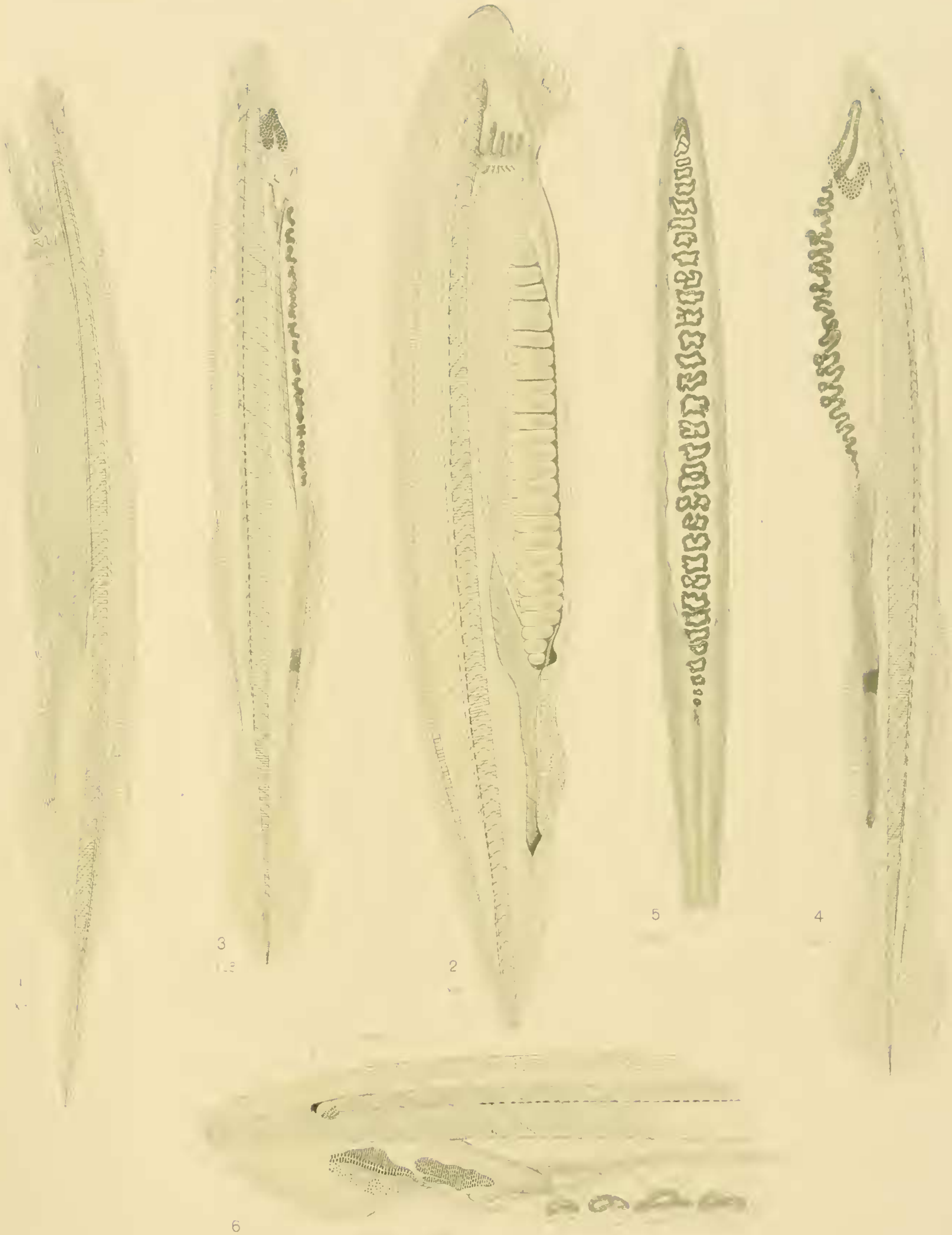
Fig. 2. *Heteropleuron maldivense.*

Fig. 3. Larva with 60 myotomes and 16 gill slits (length 5·75 mm.).

Fig. 4. An older larva with 61 myotomes and 31 gill slits (length 6·5 mm.).

Fig. 5. A ventral view of the above larva shewing the extent of gill slits in the ventral surface. The slits are seen to be of a roughly rectangular shape, the outlines being somewhat obscured by the twisting of the edges.

Fig. 6. Enlarged view of the head of Fig. 3. *e.* eye spot, *b.* brain, *p.p.* preoral pit, *p.s.o.* preoral sense organ, *end.* endostyle, *c.s.g.* club-shaped gland, *g.s.*1. first gill-slit.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